Development and evaluation of content of the mobile app Cinesia for patients with unilateral motor deficits after stroke

Desenvolvimento e avaliação do conteúdo do aplicativo móvel Cinesia para pacientes com déficits motores dimidiados após acidente vascular cerebral

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Abstract

Introduction: The incidence of stroke in adults has increased in recent years, and individuals who survive often have one or more motor and cognitive deficits. In Brazil, the Unified Health System (SUS) faces difficulties in reabsorbing the entire population that needs physiotherapy after hospital discharge. In addition, the distance to rehabilitation units in Rio de Janeiro can be far, making it impossible for some patients to receive the treatment they need. **Objective:** To create a complementary mobile application for adults with unilateral motor deficits and to evaluate its content through expert judges. **Methods:** Applied research for the construction of a mobile app with the prototyping method by Pressman. Steps: 1) literature review; 2) development of the technological framework; 3) construction of the content; and 4) construction of a prototype. The app content was evaluated using the e-Delphi Method for peer review using a Likert-type questionnaire on the Google Forms platform. **Results:** The application was developed and designed to run on the Android operating system. Three rounds were carried out to evaluate the app's content. The final average of the content validity index (CVI) of all content items was 0.85, reaching the minimum agreement of 0.80, suggested by authors. **Conclusion:** The content of a mobile app for adults with unilateral post-stroke motor deficits was developed and approved, and its content was evaluated by expert judges. We believe that this app can contribute to the promotion of physical rehabilitation in people with unilateral motor deficits after hospital discharge.

Keywords: Hospital discharge. Mobile app. Mobility limitation. Muscle stretching exercises. Neurological rehabilitation.

Resumo

Introdução: *A incidência do acidente vascular cerebral (AVC) em adultos tem aumentado nos últimos anos e os indivíduos sobreviventes apresentam frequentemente um ou mais déficits motores e cognitivos. O Sistema Único de Saúde enfrenta dificuldades em reabsorver toda a população que necessita de fisioterapia após a alta hospitalar. Além disso, a distância entre as unidades de reabilitação no Rio de Janeiro impossibilita que alguns pacientes realizem o tratamento necessário.* ***Objetivo:*** *Criar um aplicativo móvel complementar para adultos com déficits motores dimidiados e avaliar seu conteúdo através de juízes-especialistas.* ***Métodos:*** *Pesquisa aplicada para a construção de um aplicativo móvel com método de prototipação por Pressman. Etapas: 1) revisão da literatura; 2) desenvolvimento do arcabouço tecnológico; 3) construção do conteúdo; 4) construção de um protótipo. Avaliou-se o conteúdo do aplicativo pelo método e-Delphi para avaliação por pares através de um questionário do tipo Likert na plataforma Google Forms.* ***Resultados:*** *O aplicativo foi desenvolvido e projetado para rodar no sistema operacional Android. Foram realizadas três rodadas para a avaliação do conteúdo do aplicativo. A média final do índice de validade de conteúdo (IVC) de todos os itens do conteúdo foi de 0,85, atingindo a concordância mínima de 0,80 sugerida por autores.* ***Conclusão:*** *Foi desenvolvido e aprovado o conteúdo de um aplicativo móvel para adultos com déficits motores dimidiados pós-AVC e realizada a ava-liação de seu conteúdo através de juízes-especialistas. Espera-se que o aplicativo possa contribuir para a promoção da reabilitação física de pessoas com déficits motores dimidiados após alta hospitalar.*

Palavras-chave: *Alta hospitalar. Aplicativos móveis. Limitação da mobilidade. Exercícios de alongamento muscular. Reabilitação neurológica.*

Introduction

Stroke or cerebrovascular accident is one of the main causes of disability in adults, and its incidence has increased in recent years.[1] Each year, around 13.7 million cases of stroke occur worldwide. However, half of the patients are unable to restore sufficient functionality to carry out their activities of daily living, and one-third of stroke survivors may develop permanent disability. It is not surprising, therefore, that there are many studies that highlight the role of prevention, risk factors and the costs related to the disease.[1,2]

The increase in population aging and the prevalence of stroke risk factors is likely to further increase the number of people living with stroke-related disabilities. In addition, World Health Organization (WHO) projections indicate a great global demand for stroke rehabilitation services, which is of concern mainly in low- and middle-income countries, where there is a high incidence of stroke and few available rehabilitation services.[3]

Stroke survivors often have one or more deficits, whether motor or cognitive, and they require regular physical rehabilitation care and need programs aimed at minimizing their deficits.[4] Motor function deficits after stroke usually include partial or total loss of function of the upper or lower limbs on a given side, with associated muscle weakness, low endurance, lack of muscle control and even paralysis.[4] These deficits, also called unilateral motor deficits, impact the patient's independent lifestyle and decrease their performance in activities of daily living.[5,6]

Monitoring the functional status of post-stroke patients after transitioning home is significant for rehabilitation, and mobile health (mHealth) technologies may provide an opportunity to reach and follow up patients after discharge. However, the feasibility and validity of functional assessments administered by mHealth technologies are still unknown.[6] Various information technology resources have been created and used to provide rehabilitation to stroke patients, making strategies available for short-term effectiveness, but they still do not reach most of the people who need them, because of various reasons regarding costs and technological skills for their operation.[6,7]

Aiming at a better recovery after stroke and preventing its recurrence, survivors need continuous home rehabilitation, as studies[8,9] indicate that this can stimulate neuroplasticity and result in much better clinical outcomes. The main barriers to providing high-quality home rehabilitation services are high cost and being labor intensive.[2,8,9]

Resolution 58.33 of the World Health Assembly on May 16-25, 2005 states that everyone should have access to health services without the need for financial sacrifices.[10,11] However, the 2017 Global Monitoring Report on tracking universal health coverage established that at least half of the world's population does not get essential health services and that 800 million people

spend at least 10% of their household budget on health.[12]

Although Brazil has a universal public health system, private health spending is higher than public spending.[13] According to the Fiscal Aspects of Health in Brazil report, published in 2018 by the National Treasury, total health spending in Brazil is about 8.3% of the gross domestic product (GDP), with 4.5% of GDP coming from private spending and 3.8% from public spending.[13,14]

There are many factors, including health care, social support and rehabilitation, that contribute to effective recovery after periods of illness or injury. If a person does not recover well, it is more likely that an unplanned hospital readmission will be required within 30 days of discharge home.[14]

Readmissions may represent deficiencies in meeting the needs corresponding to a given disease. The shorter the interval between hospital discharge and readmission, the greater the chance that the return was potentially avoidable. Readmissions can be avoided with better management of the patient's clinical condition, hospital discharge planning and provision of resources at home to meet the patient's needs.[14]

The experience of caring for someone affected by a neurological deficit has become more and more frequent in daily life at home.[15] In many families, domestic workers who are closer to the elderly, or who develop some affinity for them, often take on the role of caregivers. without being qualified for these functions.[15,16]

In Brazil, with the implementation of Ordinance 793/2012,[17] there are available points of care in the Care Network for Persons with Disabilities, through the creation, expansion and articulation of health care points within the scope of the Unified Health System (SUS). The network covers people with disabilities that are temporary or permanent, progressive, regressive or stable, or intermittent or continuous, defining care for physical, hearing, intellectual, autism spectrum disorders, visual, ostomy and multiple disabilities within the scope of SUS.[17,18]

In the city of Rio de Janeiro, there are the Specialized Rehabilitation Centers (CER), which are regulated referral services that operate on a territorial basis and provide specialized care for people with disabilities that are temporary or permanent, progressive, regressive or stable, or intermittent or continuous and that are severe and under intensive treatment. Referrals are made by the Basic Health Care Unit, through the National Regulation System (SISREG), with clinical justification including detailed anamnesis, physical examination compatible with diagnostic hypothesis, results of complementary tests, evolution time and description of the management assumed until the moment.[19]

Not all patients who are discharged from a SUS intensive care unit (ICU) manage to be reabsorbed by the system to maintain post-hospital rehabilitation care, such as physiotherapy. According to data released by the SISREG Outpatient Transparency Portal, by January 2, 2023, there were 2256 patients on the waiting list for consultations in adult physiotherapy in the city of Rio de Janeiro, with an estimated average waiting time of 42 days.[20]

Access, equity, quality and cost are the main problems faced by universal health systems around the world.[21] In this context, electronic health (eHealth) has been seen as an important tool to face today's challenges of universal health systems, which can be defined as the use of information and communication technologies to offer and improve health services, especially in cases where distance is a critical factor.[21,22]

Data released by the Brazilian Institute of Geography and Statistics (IBGE) in 2018 indicate that the internet is used in 75% of Brazilian households and that in 99% of these households, the cellphone is used for this purpose, followed by of the microcomputer (52%), television (16%) and tablet (16%).[23] This dissemination of the internet via mobile devices led to the emergence of a subdivision of eHealth called mHealth, defined by the Global Observatory of eHealth as a medical practice or public health through wireless technology and works with disease prevention, monitoring and diagnosis. According to a survey by Startup Base, by September 2019, Brazil had 735 startups in the health area, most linked to mHealth.[22,23]

The use of smartphones in health care has the potential to increase individuals' ability to self-manage health behavior.[24] The use of mobile technology is also proving to be successful in increasing physical activity, as well as offering an opportunity to engage in acute care rehabilitation while people wait to begin therapist-led traditional stroke physical rehabilitation.[24] The ubiquity of smartphones and mobile apps has brought with it interest in leveraging this technology for stroke rehabilitation purposes.[4] There are numerous studies in the international literature focused on mobile apps as rehabilitation platforms for a variety of post-stroke deficits, including communication, cognition and fine motor skills.[24]

These mHealth strategies capitalize on the key functionalities of a mobile phone or smartphone and are strongly recommended by the WHO to fill gaps in accessibility to health services around the world.[4,24] It is important to point out that home telerehabilitation provides a viable tool to meet the rehabilitation needs of stroke survivors in resource-limited community settings in developed countries, as well as in low- and middle-income countries where the stroke burden is rapidly increasing.[25,26]

On March 18, 2020, the new coronavirus pandemic was declared, and with that, some concepts in the world regarding the use of telemedicine were modified. Evidence points to a significant advance in health care in the future.[27]

We took in consideration the conflict between hospital discharge only after the clinical condition improves, without taking into account the possibility of physical therapy rehabilitation of the patient, and due to the rise of telemedicine – especially at the time of the new coronavirus pandemic –, combined with the high percentage of users with internet access via cellphone. So, the aim of the project was to create a technological product, a mobile app for adults with post-stroke unilateral motor deficits that provides a complement to institutional extramural rehabilitation and well-being and to evaluate the content of the mobile app by expert judges.

Methods

This was a qualitative study of the construction of a mobile app aimed at patients with unilateral motor deficits after hospital discharge, with operationalization and prototyping method according to Pressman.[28] The prototyping paradigm described by Pressman in 2011had the following steps: 1) communication; 2) fast design; 3) modeling (fast design); 4) construction of a prototype; and 5) use, delivery and feedback. In this study, the first four steps were performed.

In the first step, an integrative literature review on mobile apps aimed at motor rehabilitation was carried out. In the second, the technological framework for the design and layout of the mobile app was developed. The development of the mobile app took place in partnership with a hired graphic designer, who developed the design and the technology interface, taking into account the specificity of knowledge of technologies required for the realization of the intended product. The mobile app was developed using the Unity platform and C# programming language (C Sharp). The layout was developed using the CorelDRAW program. The application was designed to run on smartphones and tablets with Android operating system.

In the third step, the content of the app was built through a search for articles related to motor rehabilitation in the main international databases. For the evaluation of the application's content by the expert judges, the modified e-Delphi method was used for peer evaluation through a Likert-type questionnaire available on the Google Forms platform, so that judges could evaluate the app's content and then decide whether or not to allow its useo.[29]

There are three ways to administer the questionnaires in the steps of the Delphi method. The first is through letters. The second requires judges to be in the same environment responding to the tool. The third method chosen for this study uses virtual resources and platforms and is called the e-Delphi method.[29]

The first questionnaire consisted of 24 questions related to the mobile app, including the graphic materials to be evaluated, and a space for suggestions, in addition to five questions about the professional profile of the evaluators, totaling 29 questions.

The first round of the Delphi method has two approaches. In the traditional approach, the first-round questionnaire consists of open-ended questions to guide ideas, present opinions, and gain consensus. The modified approach used in this study requires the investigator to identify issues relevant to the purpose of the study and requires, in advance, the development of an initial assessment instrument, so that the first-round judges the instrument's items.[29]

The Likert-type scale is one of the most used psychometric tools in studies that apply the e-Delphi method, due to the measurement system using points, allowing the assessment of the respondent's level of agreement. The points are commonly arranged numerically accompanied by a definition. The method chosen in this study was: 1. totally adequate (TA); 2. adequate (A); 3. partially adequate (PA); 4. inadequate (I); and 5. not applicable (NA).[29]

The selection of expert judges can be carried out in two ways: "by judging" (or intentional) and "snowball" (or network). The judging sample, used in this study,

was based on our opinion, selecting individuals who appeared to be a source of accurate information on the evaluated topic, while the "snowball" starts from the communication between researcher and potential judges, requiring in the initial contact indications about other members who could be involved in the study.[29]

The evaluators were invited via e-mail through an invitation letter.[29] The inclusion criteria to participate in the questionnaire were to have a degree in physiotherapy and at least one graduate degree in a related area completed. Data analysis was performed using the Google Sheets platform. The content validity index (CVI) score was calculated in the three rounds of e-Delphi questionnaires.[30] The CVI score was calculated through the sum of agreement of the items that were marked by "1" or "2" by the judges . In the case of six or more evaluating judges, a rate of not less than 0.78 was recommended. To verify the validity of new instruments, some authors suggest a minimum concordance of 0.80.[28] However, recommended values should be 0.90 or more. CVI results below the established consensus level suggested revision of the item.[30]

The project was submitted to and approved by the Ethics and Research Committee of the Federal University of the State of Rio de Janeiro (UNIRIO), under CAAE No. 49074321.7.0000.5285 and Approval No. 4.980.131.

Results

The study derived from a master's thesis.[31] The content of the mobile application was developed after reviewing the literature related to the topic, taking into account the fact that the exercises were performed without supervision by professionals. Accordingly, we decided to include functional exercises, which are already part of common daily life activities.

Initially, 22 graphic elements were included in the application, 18 videos and four pictures, containing nine functional exercises for upper limbs in video format, five functional exercises for lower limbs in video format, four changes in decubitus or transfer in video format and four positions in bed or chair in image format (Figure 1).

After the responses to the second round of the questionnaire, nine new videos were developed for patients with hemiplegia and hemiparesis grades 1 and 2 of muscle strength, six exercises for upper limbs and three for lower limbs (Figure 1).

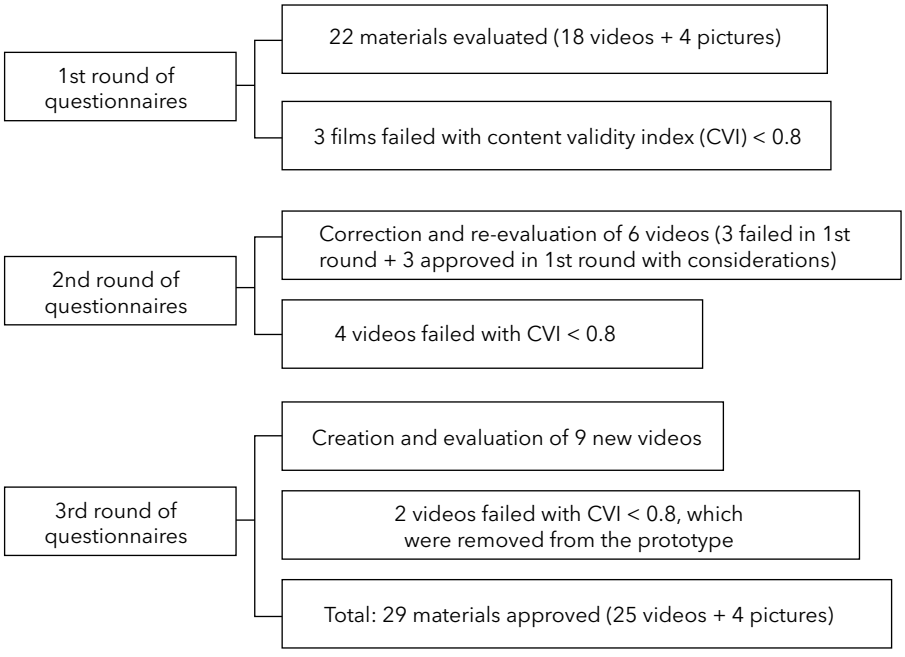

Figure 1 - Flowchart of steps of validation process.

After the result of the third round of the questionnaire, two lower limb exercises were removed from the application because they were not approved, totaling in the end 29 graphic materials, 25 videos and four images, containing 15 functional exercises for upper limbs in video format, six functional exercises for the lower limbs in video format, four changes in decubitus or transfer in video format, and four positions in bed or chair in image format (Figure 1).

The home screen of the mobile app has an informative message about the app and its suggested use. After confirming knowledge of the information, it is possible to see the option "degree of muscle strength on the weaker side", with four options next to the degrees of muscle strength to be chosen, namely 0, 1, 2, 3 or 4 (Figure 2). When selecting the current strength degree of the affected side, the exercises are updated. The screen also has four clickable items displayed in miniature-type figures, namely: *exercises for arms*, *exercises for legs*, *positioning*, *transfers*. When selecting one of these miniature items, another new window opens with the graphic element maximized, accompanied by a text caption below and the option of subtitle audio.

Figure 2 - Initial screen of the mobile app CINESIA (only available in Portuguese).

The character in the application has half of the body colored and the other half in gray tone, with the gray side representing the weaker side of the patient. The name of the application CINESIA originates from the Greek word kinesis and is a feminine noun that means ability to move, mobility, movement.[32]

In the first round of app validation, 10 questionnaires were received and properly answered by expert judges. Of the 23 items evaluated in the first round of the questionnaire, three had a CVI of less than 0.78, being considered as having failed.

The item *sitting and standing up* received the following comments from the evaluators: "Safe once there has been training for it before discharge by the physiotherapist"; "Place the chair next to a wall with the affected side facing the wall to reduce the risk of falling."; "Risk of falls"; and "Attention to the risk of falling". .

The item *climbing a 'step' with hand support* obtained the following comments from the evaluators: "Safe if patient has been trained and guided by the physiotherapist before discharge."; "Depending on the degree of weakness, risk of falls"; "Be careful with compensations in hip abduction. Perhaps guide the patient to position themselves with the most affected side very close to a wall.;" and "If you don't have enough strength in your upper limbs to hold it, maybe it's not safe".

The item *walking* obtained the following comments from the evaluators: "Once again, the video shows axillary support on the affected side, this may favor shoulder injuries..."; "Orient the companion to hold the waist so that the center of gravity is at S2 and have greater stability for walking and, in case of instability, do not generate any overload on the paretic shoulder"; "There needs to be guidance and training with a physiotherapist beforehand"; "Inspires greater care and attention"; and "Perhaps it is necessary to correct some gait maladjustment that only the physiotherapist can recognize."

The three items were changed according to the experts' suggestions and underwent a new analysis through the second round of the questionnaire on Google Forms. In addition to these items, three other items that were approved in the first round, but with some considerations by the specialists, were changed for the second round, namely:

Opening and closing a bottle: "If the priority is movement distally, it may be advisable to support the elbow, as in the previous video, to avoid shoulder compensation.";

Lift leg with hand support: "Be careful with compensations in hip abduction. Perhaps guide the patient to position themselves with the more affected side very close to a wall.", and "If you don't have upper limb strength on the paretic side, maybe it's not safe";

*Transfer from sitting to standing: "*Axillary grip on the compromised side may favor shoulder injuries".

The final mean CVI of all 23 items after the second round of the questionnaire was 0.85, reaching the minimum agreement of 0.80, suggested by authors (Table 1).[30]

Due to the result of the second round of questionnaires presenting a CVI <0.80 in four items, including previously approved items, it was decided to divide the exercises according to the degree of impairment of the patient's muscle strength. Therefore, nine new exercises were developed for patients with hemiplegia and hemiparesis grades 1 and 2, and a third round of questionnaires was carried out to evaluate the new contents. The exercises not approved by the expert judges with the explanation that they were not suitable for patients with hemiplegia and hemiparesis grades 1 and 2 were kept in the app with guidance to be performed only by patients with hemiparesis grades 3 and 4. The final mean CVI of all 23 items after the second round of the questionnaire was 0.85, reaching the minimum agreement of 0.80, suggested by authors.[30]

Of the nine items evaluated in the third round of the questionnaire, two obtained a CVI of less than 0.78, being considered as having failed and, therefore, being removed from the app: *hip flexion*, which received the comments "It depends on the amplitude of the hip and the patient's trunk control", "Afraid of the patient falling forward.", "Orient the use of pillows and supports for support in patients with trunk control deficit.", and "Necessary for the patient to perform properly without compensating for any other movement"; and *hip adduction*, which received the comments "I don't consider it safe, it depends a lot on how the patient's hip is", "I'm afraid of the patient falling forward.", and "Risk of the patient falling and compensating for some movement". The final mean CVI of the app after the third round of the questionnaire was 0.85, reaching the minimum agreement of 0.80, suggested by authors (Table 2).[30]

Table 1 - Result of the content validity index (CVI) in the first and second round of questionnaires

Item assessed	CVI¹	Opinion*	CVI²	Opinion*
Bringing out stretched arms back	1.0	Approved	-	-
Weight transfer to arm	0.9	Approved	-	-
Grasp object with arm supported	0.9	Approved	-	-
Move a bottle	0.9	Approved	-	-
Turn a bottle over	1.0	Approved	-	-
Open and close a bottle	0.9	Approved	0.7	Disapproved
Bring a spoon to mouth	1.0	Approved	-	-
Comb hair	0.8	Approved	-	-
Turn magazine pages	1.0	Approved	-	-
Bridge	1.0	Approved	-	-
"Steps" lying on one's side	0.8	Approved	-	-
Sitting and standing up	0.6	Disapproved	0.8	Approved
Climb "step" with hand support	0.6	Disapproved	0.6	Disapproved
Lift leg with hand support	0.8	Approved	0.8	Approved
Transfer from lying to sitting on edge of bed	0.9	Approved	-	-
Transfer from sitting to standing	0.9	Approved	0.4	Disapproved
Transfer from sitting on bed to chair	0.9	Approved	-	-
Transfer walking	0.5	Disapproved	0.4	Disapproved
Positioning lying face up	0.9	Approved	-	-
Positioning on side with weaker side up	1.0	Approved	-	-
Positioning on side with stronger side up	1.0	Approved	-	-
Positioning sitting	1.0	Approved	-	-
Clarity and understanding of graphic materials	0.9	Approved	-	-

Note: CVI¹ = CVI result in the first Delphi round; CVI² = CVI result in the second Delphi round; *CVI reference value ≥ 0.80.

Table 2 - Result of the content validity index (CVI) in the third round of questionnaires

Item assessed	CVI³	Opinion*
Pronation and supination of forearm	1.0	Approved
Finger flexion and extension	1.0	Approved
Wrist flexion and extension	0.9	Approved
Elbow flexion	0.8	Approved
Hair combing (hemiplegia/hemiparesis 1 and 2)	0.8	Approved
Ulnar and radial deviation	1.0	Approved
Hip flexion	0.6	Disapproved
Knee extension	0.9	Approved
Hip abduction	0.7	Disapproved

Note: CVI³ = CVI result in the third Delphi round; *CVI reference value ≥ 0.80.

Regarding the expert judges, 80% were female and 60% aged between 31 and 40 years old, and all had at least six years of undergraduate training in physical therapy, half of whom had between 10 and 20 years of training. All had a lato sensu graduate degree, 50% with a stricto sensu master's degree and 30% with a stricto sensu doctorate degree. Among the specializations, most had specialization in physical therapy in intensive care (70%), followed by neurofunctional physical therapy (40%).

Discussion

During the pandemic, mHealth has become an essential resource not only to contain the spread of the virus but also to ensure continuity of care for patients with chronic diseases.[27,33,34]

The target audience chosen for the end user of the CINESIA mobile app content is justified by the fact that stroke is the second cause of death in the world and, among survivors, temporary or permanent neurological and/or motor deficits are acquired, requiring special care to perform activities of daily living, evolving with a certain degree of dependence. Studies aimed at the use of mobile apps for motor rehabilitation show a greater tendency towards neurological rehabilitation apps focused on patients affected by stroke.[35-37]

According to integrative reviews carried out,[25,38] few mobile apps in health were intended for their final audience target, the patients. It is possible to observe, however, a change in the focus profile of app developers, since recent studies[25,38] show a greater tendency for patients to be the end user of mobile apps, such as the mobile CINESIA.[38]

A limiting factor of the Delphi method, as well as most survey studies, is the low response rate. Studies estimate abstention ranging from 30 to 50% of respondents in the first round and from 20 to 30% in the second. In addition, a meta-analysis has shown that the proportion of respondents in surveys conducted virtually is, on average, 11% lower than other modes of study. The literature is consistent with the study's finding, given that the number of respondents reached in the three rounds of the questionnaire only reached the minimum value suggested by the authors.[22] The high level of agreement with the exercises selected for the app's content can be explained by their selection criteria, including, for the most part, functional exercises with a low level of difficulty.

The study has some limitations. In addition to the sample size of the expert judges being small, information regarding the dose of the exercises was not included in the evaluation of the content of the mobile app. A new round including evaluation of the intensity, frequency and duration of the exercises seems to be interesting to be carried out later.

Conclusion

A mobile app was developed for adults with post-stroke unilateral motor deficits, and its graphic content was evaluated by expert judges after three rounds of questionnaires. The final mean CVI of the evaluated items in the app reached the minimum agreement suggested by authors, and therefore, its content was considered approved.[30] A new round of questionnaires seems to be interesting to evaluate the dose of the exercises to be performed.

It is expected that the app on screen can contribute to the promotion of physical rehabilitation of people with unilateral motor deficits after hospital discharge, providing improvements in the scope of functional autonomy for daily activities, health, self-esteem and quality of life. It represents, above all, a contribution of physiotherapy to address a collective health problem, considering its perspectives of community reach.

Authors' contributions

IPAV was responsible for curating data, acquiring funding, research, methodology and, with WCAM, for writing and revising the article. Both authors approved the final version.

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